

2.1.2. FLASK SAMPLE CARBON DIOXIDE MEASUREMENTS

Carbon dioxide measurements of air samples collected throughout the CMDL cooperative flask sampling network during 1993 continued to provide evidence for recent unexplained variations in the global carbon cycle. Provisional mean CO₂ mixing ratios for 1993, along with revised values for 1991 and 1992, are reported for 32 sites in Table 2.2. This is the first full year of data from the Baltic Sea (BAL) and Vestmanaeyjar, Iceland (ICE). Three new sites were added to the network in 1993: Hegyhatsal, Hungary (HUN); Wendover, Utah (UTA); and Gozo, Malta (GOZ).

TABLE 2.2. Provisional 1991-1993 Annual Mean CO₂ Mixing Ratios From Network Sites

Code	Station	CO ₂ (ppm)		
		1991	1992	1993
ALT	Alert, N.W.T., Canada	357.3	357.5	357.7
ASC	Ascension Island	353.9	355.2	355.8
BAL	Baltic Sea			359.9
BME	Bermuda (east coast)	356.1	357.1	356.8
BMW	Bermuda (west coast)	356.6	356.3	357.3
BRW	Barrow, Alaska	357.6	357.5	358.2
CBA	Cold Bay, Alaska	357.3	357.3	357.8
CGO	Cape Grim, Tasmania	352.8	353.6	354.5
CHR	Christmas Island	355.4	356.5	357.3
CMO	Cape Meares, Oregon	356.7	356.4	358.5
GMI	Guam, Mariana Islands	356.1	356.4	356.6
HBA	Halley Bay, Antarctica	353.2	354.6	355.1
ICE	Vestmanaeyjar, Iceland			357.4
IZO	Izaña Observatory, Tenerife	[]	356.2	357.5
KEY	Key Biscayne, Florida	356.5	357.3	358.4
KUM	Cape Kumukahi, Hawaii	355.8	356.3	357.1
MBC	Mould Bay, Canada	357.6	357.4	357.8
MHT	Mace Head, Ireland	[]	356.1	356.7
MID	Midway Island	357.0	356.8	357.5
MLO	Mauna Loa, Hawaii	355.6	356.5	356.9
NWR	Niwot Ridge, Colorado	356.1	356.9	357.4
PSA	Palmer Station, Antarctica	353.2	354.2	355.1
QPC	Qinghai Province, China	[]	356.6	357.3
RPB	Ragged Point, Barbados	355.9	356.0	356.7
SEY	Mahé Island, Seychelles	353.9	354.9	356.0
SHM	Shemya Island, Alaska	356.7	357.2	357.7
SMO	American Samoa	354.2	354.9	355.6
SPO	South Pole, Antarctica	353.1	354.1	354.8
STM	Ocean Station M	356.5	356.6	357.5
SYO	Syowa Station, Antarctica	353.3	354.2	354.5
TAP	Tae-ahn Peninsula, S. Korea	359.7	360.5	360.4
UUM	Ulaan Uul, Mongolia		356.6	357.1

Square brackets indicate insufficient data to calculate annual mean.

The selection of new network sites continues to be motivated by the need to include measurements from continental regions in global carbon cycle analyses. Three examples of this strategy are shown in Figure 2.3, where the CO₂ data for Ulaan Uul, Mongolia (UUM); Tae-ahn Peninsula, South Korea (TAP); and Qinghai Province, China (QPC) are plotted. The remote desert site at UUM and the high plateau location of QPC appear to be excellent sites for sampling well-mixed continental air, unaffected by local vegetation or pollution sources of CO₂. The coastal site at TAP is more heavily influenced by local anthropogenic sources, as evidenced by the higher variability, but it has already yielded useful information relevant to regional CH₄ emissions [Dlugokencky *et al.*, 1993].

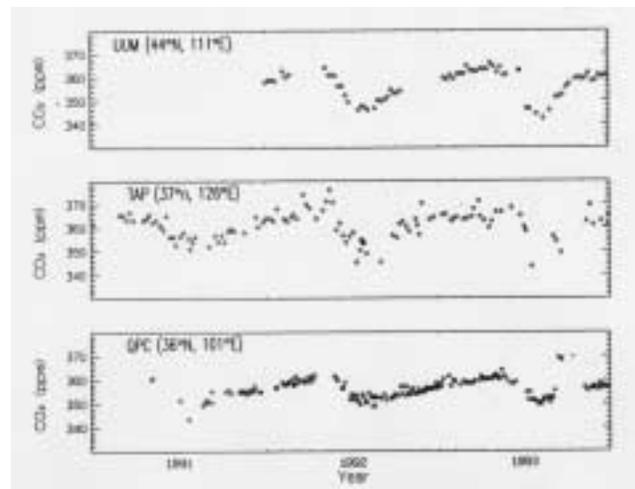


Fig. 2.3. CO₂ mixing ratios determined for flask samples collected at Ulaan Uul, Mongolia (UUM); Tae-ahn Peninsula, South Korea (TAP); and Qinghai Province, China (QPC) from 1991 through 1993. The square symbols represent the average CO₂ mixing ratios for two flasks collected in series.

Sampling was temporarily discontinued in the Pacific Ocean from the Blue Star Line ships *Southland Star*, PAC (August) and *Wellington Star*, PAW (July), and in the South China Sea from the Chevron ship *Carla A. Hills*, SCS (February). Pacific Ocean sampling was restarted in October from the Blue Star Line ship *California Star* and given the 3-letter code OPC. Sample collection resumed in the South China Sea from aboard the *Great Promise* in November, retaining the same site code, SCS.

The lower-than-average rate of increase of atmospheric CO₂ observed in 1992 continued in 1993. The CO₂ data for Mould Bay and South Pole are shown as examples in Figures 2.4 and 2.5. An analysis of the flask network data through 1992 yielded a globally averaged CO₂ growth rate of 0.6 ppm yr⁻¹ from 1991 to 1992 [Conway *et al.*, 1994]. The average growth rate for the latitude band from 30° to 90°N, based on data through the end of 1992, was essentially zero. The global and semihemispheric growth rates through 1993 are given in Table 2.3.

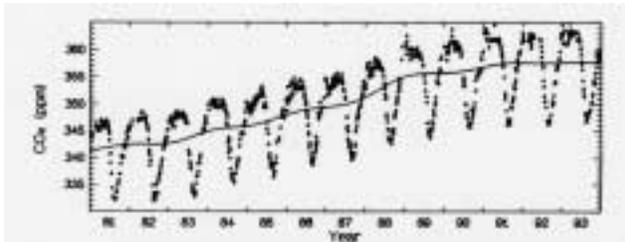


Fig. 2.4. CO₂ mixing ratios measured in flask samples collected at Mould Bay, Canada (MBC). The square symbols represent the average value for two flasks collected in series. The smooth curve represents the deseasonalized long-term trend. Note the near-zero increase in 1992 and the slight increase in 1993.

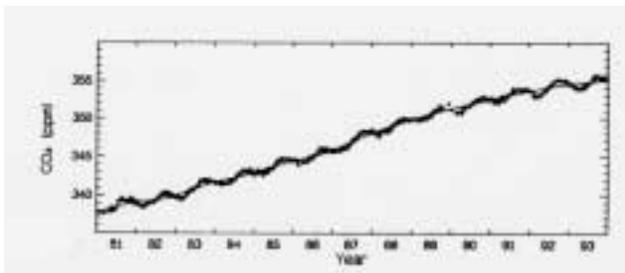


Fig. 2.5. CO₂ data and long-term trend for SPO. Note that the 1992-1993 growth rate decline is not as pronounced as at Mould Bay.

The globally averaged CO₂ increase from 1992 to 1993 was only ~0.7 ppm, about half the average 1981-1991 annual increase. Most of the change in the 1992-1993 global growth rate compared with 1991-1992, is due to a recovery of the growth rate from 30° to 90°N to 0.7 ppm yr⁻¹. The CO₂ growth rates for the other semihemispheres during 1992-1993 were nearly equal to or slightly less than during 1991-1992. The variation with time of the globally averaged CO₂ growth rate is shown in Figure 2.6. The uncertainty of this curve is ~0.2 ppm yr⁻¹ from 1981 to 1987, and ~0.1 ppm yr⁻¹ thereafter. For the last 6 months of 1993, this curve is less certain because the end of the curve is poorly constrained until several months of 1994 data are included. A preliminary look at available 1994 data suggests that the upturn of the CO₂ growth rate at the end of 1993, evident in Figure 2.6, will continue into 1994.

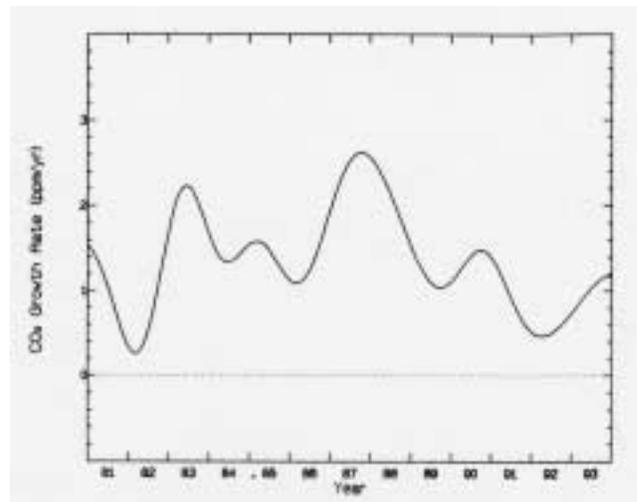


Fig. 2.6. The globally averaged CO₂ growth rate obtained from the flask network data. Because this curve is based on data only through the end of 1993, the last 6 months must be viewed with caution. Preliminary 1994 data suggest that the upturn of the growth rate in 1993 will continue into 1994.

TABLE 2.3. Semihemispheric and Globally Averaged CO₂ Growth Rates (ppm yr⁻¹)

Period	30-90°S	0-30°S	0-30°N	30-90°N	Global
1981-1991	1.43	1.48	1.51	1.59	1.50
1991-1992	0.93	0.89	0.62	0.09	0.64
1992-1993	0.87	0.82	0.59	0.67	0.74